The Role of Comparative Advantage and Learning in Wage Dynamics and Intrafirm Mobility: Evidence from Germany

Stéphanie Lluis [1]
Economics Department, Université de Montréal
CRDE and CIRANO

13th February 2002

[1] I thank Thomas Lemieux and Claude Montmarquette for their enduring support through this project. I am also grateful to Tom Crossley, Nicole Fortin, Robert Gibbons, David Green, Jennifer Hunt, Craig Riddell, and Daniel Parent for valuable comments and suggestions. Special thanks to Lars Vilhuber for his help in accessing the GSOEP data. Financial and logistic support by CRDE and CIRANO at Université de Montréal is gratefully acknowledged.

Abstract

This paper analyzes the dynamics of wages and workers' mobility within firms with a hierarchical structure of job levels. The theoretical model proposed by Gibbons and Waldman (1999), that combines the notions of human capital accumulation, job rank assignments based on comparative advantage and learning about workers' abilities, is implemented empirically to measure the importance of these elements in explaining the wage policy of firms. Survey data from the GSOEP (German Socio-Economic Panel) are used to draw conclusions on the common features characterizing the wage policy of firms from a large sample of firms. The GSOEP survey also provides information on the worker's rank within his firm which is usually not available in other surveys.

The results are consistent with non-random selection of workers onto the rungs of a job ladder. There is no direct evidence of learning about workers' unobserved abilities but the analysis reveals that unmeasured ability is an important factor driving wage dynamics. Finally, job rank effects remain significant even after controlling for measured and unmeasured characteristics.

Key words: Wage dynamics, intra-firm mobility, human capital accumulation, unobserved heterogeneity, learning

1 Introduction

The question of how wages are determined is central to the study of labour economics. The large body of theoretical work that attempts to understand the factors governing wage outcomes offers several possible explanations. Some of the models are based on the concepts of human capital (Becker (1975), Hashimoto (1981)), learning (Harris and Holmstrom (1982)), and matching (Jovanovic (1979)). Other models look at the role of incentives in compensation. Examples include tournament theory (Lazear and Rosen (1981)) and efficiency wage theory (Shapiro and Stiglitz (1984)).

The large variety of theoretical explanations has generated an extensive empirical literature which has attempted to both utilize and distinguish between the competing theories. This literature has focused on aspects of the question such as the return to interfirm mobility on the part of workers (Bartel and Borjas (1981), Simonet (1998), Topel and Ward (1992)), the covariance structure of earnings across workers and firms (Parent(1995), Topel and Ward (1992)), and inter-industry wage differentials (Krueger and Summers (1988), Gibbons and Katz (1992)). Thus far, little empirical work has been done on questions relating to how jobs are assigned to workers and the resulting effects on the evolution of intrafirm wage structures and mobility within the firm.

This paper presents an empirical study of the common features characterizing the wage policy of firms. More precisely, it analyzes what is driving the dynamics of wages and the workers mobility within the firm. On one extreme, one might think about pay settings and job assignments being regulated according to automatic bureaucratic rules, applying to everyone. On the other extreme, pay raises and promotions would be determined by the worker's level of ability where only high ability workers would benefit from it. Another possibility is one in which wage growth and mobility would be driven by random productivity shocks. To analyze the question I use the theoretical framework proposed by Gibbons and Waldman (1999) in which, given a hierarchical structure of job levels within firms, the determination of wages depends on how the worker's abilities are evaluated within a job rank, given that each job rank has different skill requirements. The model specifies a wage equation integrating the elements of human capital accumulation, job assignment based on comparative advantage and learning about the worker's ability to explain the dynamics of wages and promotions inside firms. This paper analyzes the importance of these elements in explaining the wage policy of firms.

The idea that the structure of wages within firms might be empirically important is not new to labour economists. Previous empirical studies on the subject, however, have mainly been restricted to providing analysis of specific questions on wage determination within the firm without real attempt at relating them to the predictions of a formal theory. Other studies present stylized facts specific to one or a few firms and although very informative, the conclusions remain restricted to the type of firm analyzed.

Doeringer and Piore (1971) are among the first to present a detailed descriptive analysis of the compensation schemes within a small sample of American firms, but attempts to formalise their analysis are still in the early stages. One strand of the literature which examines these issues, follows in the footsteps of Doeringer and Piore by using detailed observations on one or a few firms. Chiappori, Salanié and Valentin(1999) take an econometric approach, using data on a large French firm, to study questions related to "early starter-late beginner" effects (a prediction of the learning theory) on the wages of individuals who remain within the institution. However the data is specific to one firm, and they restrict the analysis to one particular aspect of the dynamics of wages and promotions. Namely, they test the fact that for two workers in a firm having the same level of wage in one period, the worker with the lowest wage the period before (defined as the "late beginner") has a higher expected wage next period. Baker, Gibbs and Holmstrom (1994 a,b) study several aspects of the internal wage structure of one medium sized U.S firm but their analysis is a descriptive one. An alternate approach is taken by McCue (1996), who uses the Panel Study of Income Dynamics to examine the importance of promotions and intrafirm mobility on wage growth. She estimates hazard models of intrafirm mobility but does not attempt to relate her findings to the theoretical literature.

A number of stylized facts emerge from the empirical literature on the internal wage policy and mobility within the firm since the last twenty years. First, the main finding on intrafirm mobility concerns serial correlation in promotion rates.[1] Holding tenure in the current job constant, promotion rates decrease with tenure in the previous job. A related finding (although reported in only one firm) is that demotions are really rare.[2] Second, nominal wage cuts are very rare but real wage cuts are much more common. Partly because nominal wage increases are rather insensitive to inflation, zero nominal increases are not rare.[3] Third, the dynamics of wages within the firm exhibit serial correlation in the sense that a real wage increase (decrease) today is serially correlated with a real wage increase (decrease) tomorow.[4] Finally, studies that analyze the relationship between wages and intrafirm mobility find that wage increases upon promotion are larger than without promotion.[5] However, wage increases upon promotion are small compared to the difference in average wages between two job levels. In other words, significant variations in wages remain within each level so that wages are not tied to levels. In addition, wage increases forecast promotions in the sense that those who receive larger wage increases get promoted more rapidly.[6]

Collectively, these observations pose a challenge to the existing theoretical literature, as none of the existing theories can explain all of these stylized facts. In response to this challenge, Gibbons and Waldman (1999) propose a synthesized model which combines on the job human capital accumulation, job assignment based on comparative advantage and learning dynamics. The predictions of their model are consistent with most of the stylized facts found in the empirical literature. The objective of this paper is to implement empirically the Gibbons and Waldman model and perform the estimation on a large sample of firms in order to test its ability to explain the common features characterizing the wage policy of firms. In addition, estimating the model on the sam-

[1] Rosenbaum (1984), Spilerman and Petersen (1993), Baker, Gibbs and Holmstrom (1994 a,b), Podolny and Baron (1995) and Chiappori and al. (1996).

[2] Baker, Gibbs and Holmstrom (1994 a,b)

[3] Baker, Gibbs and Holmstrom(1994 a,b) in the case of one firm and Card and Hyslop (1995) find identical conclusions using the CPS and PSID. A related finding is found in Peltzman (2000). Using data from the BLS, it is found that output prices increase more than they decrease in response to shocks in the cost of inputs. Increases in firm's labor costs would therefore induce real wage decreases.

[4] Hause (1980), Lillard and Weiss (1979) and Baker, Gibbs and Holmstrom (1994 a,b).

[5] Murphy (1985) Baker, Gibbs and Holmstrom (1994 a,b) and McCue (1996).

[6] Baker, Gibbs and Holmstrom (1994 a,b). McCue (1996) finds that a high wage today is positively correlated to promotion tomorrow, and, in the same spirit, Topel and Ward (1992) find that prior wage growth affects mobility even after controlling for the current wage.

ple of workers remaining with their firm and comparing the results to those obtained from the sample that includes firm changers allows to distinguish between firm specific effects and individual specific effects transferable across firms in the analysis of the wage dynamics.

The estimation is performed using GMM techniques applied to the longitudinal data from the German GSOEP over the period 1986-1996. This survey provides information on the workers mobility between and within the firm and, more importantly for the analysis hereafter, detailed information on the rank of the worker in his current occupation is available. The German case is an interesting application of the model because the German labour market is thought to differ significantly from the U.S labour market (which provides many of the observations which motivate Gibbons and Waldman's research). Particularly, as shown by Simonet (1998), interfirm job mobility declines much earlier in a workers' career in Germany than in the U.S. This suggests the possibility that *intra*-firm mobility may be more important in Germany than in the United States. In addition, because of the strength of trade unions and their close relationship with employer's associations, German firms have to deal with bureaucratic rules governing the setting of wages and job assignments, which could affect the returns to intrafirm mobility on the part of German workers. Therefore it is not clear, a priori, whether the factors of comparative advantage and learning, which seem to explain the U.S experience, are more or less important in Germany.

The paper is organized as follows. Section II provides a description and a first analysis of the data. Section III sketches the theoretical model of Gibbons and Waldman and establishes the framework of the econometric analysis and how this relates to the theory. Section IV presents the results of the estimations, and Section V concludes the paper.

2 The Data

The data for the analysis come from the German Socio-Economic Panel. The GSOEP is a representative longitudinal study of private households conducted every year in

Germany since 1984. This survey is unique for the analysis hereafter because it provides information on movements between and within firms through a question about changes in the worker's employment situation in the previous year. Most importantly, there is detailed information on the rank occupied by the worker within his current occupation. To my knowledge, this type of information is not available in any other surveys. These two pieces of information are central to the study of wage and mobility dynamics within the firm. Another advantage is that information is collected over a large sample of individuals and therefore, the analysis of wage dynamics and intrafirm mobility can be done for a large sample firms.

2.1 Data Selection

I considered information on the usual individual characteristics such as age, education, sex, marital status and nationality. Information on bonuses received during the previous year and on the duration of the employment contract (unlimited or limited length) are also available. Wages are given on a monthly basis, corresponding to the month preceding the time of the survey. For the firm's characteristics, the counterpart of using survey data is that precise information on that part is limited. I used the type of industry, whether the firm belongs to the public sector and firm size.

The panel spans the years 1985 to 1996 because information on mobility within the firm is not available in 1984. Since it covers the German reunification, I have excluded data on the former East German population to keep the pre and post unification samples comparable. I have selected individuals aged between 20 and 65 who are working at the time of the survey on a full-time basis. I have excluded self-employed workers and put a restriction on wages excluding any observations below 500 DM per month.[7] Finally, I considered the sample of workers remaining with their firm over all the period, reporting either mobility within the firm or no change in job situation. This leaves us with a sample consisting of 11159 observations (3487 workers). Appendix 1 describes the data selection in more details and provides the sample means of the main variables

[7] Since in Germany, the minimum wage varies by industry, this bound should give a reasonable minimum in order to exclude outliers for wages without loosing observations on low wage workers such as trainees.

used.

The objective of the next two subsections is to describe the data and to examine, in the spirit of the Gibbons and Waldman model, the links between intrafirm mobility, wage growth and hierarchical levels of jobs for German workers. Two questions will be addressed: What are the main determinants of intrafirm mobility? By which channels does intrafirm mobility influence the determination of wages from one hierarchical level to the next? That is, how are individual skills effects and hierarchical level effects reflected in the wage premium associated to being in a higher rank on the job ladder? The analysis of these points is based on a logit model of the probability of intrafirm mobility and on inter-rank wage differentials estimations.

2.2 Intrafirm Mobility and Individual and Firm Characteristics

In this subsection, I examine the effect of worker and firm characteristics on intrafirm mobility. The estimation method is based on a binomial logit model in which the benefit from moving within the firm is a function of observable characteristics. The alternative to the choice of intrafirm mobility is no changes in employment situation within the firm. [8]

Starting with a set of base characteristics, I look at the effect of adding particular variables of interest on the probability of intrafirm mobility. Among these variables are lagged bonuses and lagged rate of wage growth. [9] If mobility within the firm is driven by the evolution of the workers productive abilities, previous wage growth, where wages reflect the evaluation of abilities, should significantly increase the chances of future mobility within the firm. In the same vein, obtaining a bonus is a signal of improvement in the worker's productive abilities and should have a positive impact on future mobility.

Among the base characteristics, I include dummies for nationality, sex and marital status. Years of education are divided into three levels: primary (up to 10 years), high school (11 to 13 years) and college (14 years and more). Finally, I considered a quadratic

[8] Appendix 2 presents the frequencies of the different types of mobility.

[9] The lag is such that bonuses and wage growth are considered the year before mobility within the firm.

function of tenure defined as the number of years worked with the firm. Concerning the characteristics related to the firm, I include a dummy for large firms (2000 employees or more), the duration of the employment contract (unlimited or not), eight industry dummies [10] and a public sector dummy.

Results are shown in column 2 of Table 2.1 [11] for the baseline model (column 3 shows the marginal effect of each variables on the probability of intrafirm mobility), and column 4 and 5 for the effect of adding lagged bonuses and lagged wage growth. Column 6 shows the specification containing all the variables and column 7 the marginal effect of these variables.

From column 2, one can see that college degrees increase significantly the probability of intrafirm moves (relative to primary school). We can notice the negative effect of tenure within the firm on intrafirm mobility suggesting that workers mobility within the firm occurs mostly at the beginning of the worker's career. In addition, we see that married individuals have a significantly lower probability of intrafirm mobility. On the other hand, nationality and gender have no significant impact. For the characteristics related to the firm, we unsurprisingly see that being in a large firm significantly increases the likelihood of intrafirm mobility and but that the future mobility is independent of whether the firm is in the public sector or whether the labour contract is of determinate length.

Introducing lagged bonus, as in column 4, has a particular impact on the variables. One can first see that the impact is significantly negative: having received a bonus last year decreases the chance of intrafirm mobility today. One interpretation is that bonus would substitute rather than complement intrafirm mobility. On the other hand, bonus and promotion could be closely related and not distinguishable, the negative impact of lagged bonus could then reflect that last year's mobility (and bonus received) is negatively correlated to the chance of mobility today.

[10] I used the International Standard Industrial Classification (ISIC).

[11] Given that the dependent variable has few responses ($y = 1$) compared to non responses, using a probit model might produce different results. I reestimated the model with the normal distribution. Results (available on request) are similar in which they lead to the same conclusions in terms of marginal effect coefficient and significance of the coefficients.

Introducing lagged wage growth in column 5 also has a noticeable impact on the other variables. First, it increases significantly the probability of intrafirm mobility next period. The coefficient is particularly large compared to the others. In addition, college education is no longer significant. The results for all the other variables remain unchanged compared to column 2 so that the main effect of controlling for lagged wage growth is on college education. Lagged wage growth may be a more accurate measure of individual skills than the level of education, providing a better signal of ability for mobility decisions. Finally, the results of column 6 where both the lagged bonus and the wage growth are added are similar to those of column 5. Controlling for the lagged bonus does not alter the relatively strong impact of lagged wage growth on intrafirm mobility.

Based on the idea that part of wage growth reflects the worker's productive abilities, the significant impact of lagged wage growth on intrafirm mobility provides a first piece of evidence supporting the role of ability as driving the worker's mobility within the firm. In order to raffine the analysis of the interactions between intrafirm mobility and the dynamics of wages within the firm, the next section investigates the relation between the wages and the different ranks that the worker can reach within his or her job. In particular, I am interested in the way individual characteristics compared to job related characteristics are reflected in wages. To analyze this point, I use the information on the different ranks of each occupation to establish inter-rank wage differentials.

2.3 Inter-Rank Wage Differentials

This section analyzes the contribution of job ranks relative to individual characteristics on wages by estimating the impact of the worker's skills on inter-rank wage differentials. In a second step, I present preliminary evidence on the importance of unobserved ability in the determination of wages and analyze whether comparative advantage based on measured ability is important.

An interesting feature of the GSOEP survey that is rarely found in other surveys is that it provides information on the level or rank occupied by the worker in his current job. Occupations are grouped in five categories: Blue-collar, white-collar, civil servant, trainee and self-employed. I considered the first three given that self-employment is not relevant for the analysis and that the trainee category is not in itself an occupation.[12] Each occupation is divided in several levels according to the qualification and responsibility requirements. Since the number of ranks is not the same for all the jobs, I have defined 4 ranks based on a more general qualification criterion:

1. unskilled or semi-skilled work
2. skilled work
3. highly skilled work
4. executive work

Appendix 3 reports the raw wage differentials (relative to the first rank) and average individual characteristics by rank. The differentials increase along the ladder but in different proportion depending on the type of occupation with white-collared workers showing the highest differentials in each rank. Although one might expect that these rank wage premium reflect the increasing responsibilities and tasks complexity related to the higher ranks, one can observe a positive correlation with measures of individual ability such as education. The link with the other characteristics is however less clear. A global measure of the workers's individual characteristics would be more convenient for the analysis of the interaction between the worker's abilities and job rank and its effect on wage outcomes.

In order to obtain a global impact of individual characteristics on wages, I summarized the individual characteristics into one variable interpreted as the worker's skill. To do so, I considered a OLS regression of the wage level on education, marital status, sex, nationality, experience and squared experience, industry and occupation type for the entire original sample of workers. I used the estimated coefficients related to education, marital status, gender, nationality and experience to compute the estimated wage based on these characteristics for workers remaining with their firm.[13]

[12]Individuals reporting trainees who were also reported in one of the other occupations have been retained.

[13]This index, reported in the last column of Appendix 3 Table, has been normalized to 0.

Column 1 of Table 2.2 presents the results of a regression of wages on rank dummies with controls for occupations and industries. One can notice that those coefficients are significant and are lower than the raw wage differentials of the Appendix 4 Table (0.49, 1.67 and 2.46 in the aggregate definition of ranks) when no controls have been considered. Column 2 of Table 2.2 considers the impact of adding the skill variable on rank effects. It shows that the skill variable is highly significant and controlling for skills reduces the impact of the rank dummies. However, the wage differentials are still significant, increasing by rank from 0.12 for rank 2 to 0.68 for rank 3 and 1.20 for rank 4 (all with respect to rank 1).

The next column of Table 2.2 presents the results of a fixed-effect estimation in order to assess the presence of unmeasured (by the econometrician) individual ability. Assuming that it is time invariant and equally valued in the different ranks, it is possible to eliminate (or control for) this term by using first difference method. If unmeasured ability does not matter in the determination of wages, the fixed-effect estimation results should be similar to the OLS results. One can see from Column 3 that the fixed-effect coefficients on ranks have dropped significantly, although still significant. This suggests that part of the rank wage premium is explained by unmeasured skills and part of it still reflects rank effects.

The notion that workers have a comparative advantage in some job ranks is equivalent to say that along the successive rungs of the job ladder, skills are differently rewarded and that workers sort themselves into a given rank. Column 4 of Table 2.2 considers the possibility that comparative advantage and self-selection operate on measured skills. To take this into account, I included to the baseline regression of column 1, interactions of the skill index and the worker's job rank. One can see that the coefficients on the interactions are significant. A test of equality of these coefficients leads to the rejection of the null ($\chi^2(3)$ of 103.43) which confirms the existence of distinct valuations of measured skills in each rank.

The analysis of Section II has shown that past wage growth has a noticeable impact on the likelihood of mobility within the firm. The wage premium associated with the different ranks that the worker can attain in his career do not entirely reflect the differentials in task and responsibility requirements (rank effects) but also the differentials in measured individual skills. Moreover, there is evidence that each job level is differently sensitive to measured skills so that workers may self-select into the different levels having a comparative advantage in one level based on their measured skills. Finally, the results on the first difference estimation lead us to suspect that unmeasured ability may also matter in the explanation of the inter-rank wage differentials and thus, in the wage dynamics. All together these results suggest that the worker's ability seem to be a good candidate in the explanation of what is driving the wage dynamics and mobility within the firm. The next section present a the Gibbons and Waldman model in which ability drives job level assignments and wage dynamics.

3 Model and Econometric Framework

This section summarizes the Gibbons and Waldman model of intrafirm mobility and wage determination and highlights the model's main predictions. The aim of the model is to characterize the relationship between a worker's career path and the evolution of his wage within the firm. It integrates wage determination and job assignments in a dynamic context, where the wage policy of the firm is based on comparative advantages and learning. In other words, it endogenizes workers' choices of job rank as workers are assigned to the job rank that better reward their productive abilities. In addition, it endogenizes mobility between job ranks because, if the productive abilities of the workers are not perfectly observed, both the firm and the worker learn about it and changes in expected ability lead the worker to move to another rank of the job ladder.

More precisely, firms are modeled as consisting of various potential job assignments and, because jobs are differently sensitive to ability, comparative advantage determines the assignment rule on the basis of output maximization. The dynamics is introduced in the model by considering that output grows with the workers' accumulation of human capital or productive abilities each period. In addition, output grows at a different speed depending on the level of innate ability of the worker. All the workers end up reaching the upper level of the job ladder but some get there faster than others. When innate ability is not perfectly observed, learning takes place and wages and mobility within the firm are driven by the evolution of expected ability.

3.1 Summary of the Model

The model consists of identical firms operating in a competitive environment and producing output using labour as the only input. All firms consist of a three-level job ladder where jobs are indexed by $j = 1, 2$ or 3. Jobs are defined in advance, independent of the people who fill them. Both firms and workers are risk-neutral and have a discount rate of zero.

A worker's career lasts for T periods. Worker i has innate ability, denoted by θ_i, which can be either high (θ_H) or low (θ_L). The worker has also effective ability, η_{it}, defined as the product of his innate ability and some function f of his labor-market experience x_{it} prior to period t:

$$\eta_{it} = \theta_i f(x_{it}) \text{ with } f' > 0 \text{ and } f'' \leq 0 \tag{1}$$

The production technology is such that if worker i is assigned to job j in period t then he produces output y_{ijt} where:

$$y_{ijt} = d_j + c_j(\eta_{it} + \varepsilon_{ijt}) \tag{2}$$

where d_j is the value of job j independent of the worker's characteristics and c_j measures the sensitivity of job j to effective ability. The constants c_j and d_j are known to all labor-market participants and it is assumed that $c_3 > c_2 > c_1$ and $d_3 < d_2 < d_1$. ε_{ijt} is a noisy term drawn independently from a normal distribution with mean zero and variance σ^2. Wages are determined by spot-market contracting. More precisely, at the beginning of each period, all firms simultaneously offer each worker a wage for that period and each worker chooses the firm that offers the highest wage. Hence, competition among firms yields wages equal to expected output.

$$w_{ijt} = Ey_{ijt} = d_j + c_j\eta_{it} = d_j + c_j\theta_i f(x_{it}) \tag{3}$$

Efficient task assignment is obtained in the sense that a worker is assigned to the job that maximizes his expected output.

In the case of perfect information, θ_i, is common knowledge at the beginning of the worker's career and therefore η_{it} is always known. In this case, job assignments and wages in equilibrium are given according to the following rule:

1. If $\eta_{it} < \eta'$ then worker i is assigned to job 1 in period t and earns $w_{it} = d_1 + c_1\eta_{it}$.
2. If $\eta' < \eta_{it} < \eta''$ then worker i is assigned to job 2 in period t and earns $w_{it} = d_2 + c_2\eta_{it}$.
3. If $\eta_{it} > \eta''$ then worker i is assigned to job 3 in period t and earns $w_{it} = d_3 + c_3\eta_{it}$.

where η' (η'') denotes the effective ability level at which a worker is equally productive at jobs 1 and 2 (2 and 3). In equilibrium, the workers climb the successive rungs of the job ladder as they gain experience.

The model under perfect information can explain most of the stylized facts of the empirical literature. Particularly, the model exhibits the absence of demotions, serial correlation in wage increases and in promotion rates, and the fact that wage increases predict promotions and explain only a fraction of the difference in average wages across levels.

More precisely, there are no demotions in equilibrium because effective ability increases monotonically. Serial correlation in wage increases occurs because effective ability grows differently for each worker due to their different levels of innate ability. That is, for a given level of experience, high ability workers will get higher wage increases than low ability workers and the same ordering will hold for wage increases at all experience levels.

The model is able to explain serial correlation in promotion rates for the same reasons. If η' and $\eta'' - \eta'$ are both sufficiently large then high ability workers are promoted to job 2 more quickly and spend less time on job 2 before being promoted to job 3. Moreover, since those who receive larger wage increases are also those who are promoted to job 2 earlier in their careers, wage increases predict promotions.

Finally, wage increases upon promotion explain a fraction of the difference between average wages across levels because, on average, part of the workers at higher levels are more experienced and the difference between average wages at different levels is given by the average experience or effective ability accumulated. This difference is bigger than the average wage increase at promotion which captures the value of only one year of experience.

In the case of perfect information, however, the explanation for the large wage increases upon promotion is not fully satisfactory. The model predicts average wage increases at promotion are higher than if the worker remains in his current job because increases in effective ability are valued in part at the rate of the current job (c_j) and in part at the higher rate of the next job (c_j) if promotion occurred. For the same reason, however, the model predicts that the average wage increases after promotion which, according to the empirical findings, should not be the case. Moreover, the monotonicity of the effective ability accumulation function precludes the possibility of real wage decreases.

When information on innate ability is imperfect (but symmetric), workers and firms start with the initial belief p_0 that a given worker is of innate ability θ_H and with $1-p_0$ that he is θ_L. Learning takes place at the end of each period when the realization of a worker's output for that period is revealed. Learning occurs gradually because of the productivity shock ε_{ijt}, which introduces noise into the output produced.

To be precise, each period a worker's output provides a noisy signal, z_{it}, about his effective ability where:

$$z_{it} = (y_{ijt} - d_j)/c_j = \eta_{it} + \varepsilon_{ijt}$$

Note that z_{it} is independent of job assignment so that learning takes place identically across jobs. The agents' expectations of the innate ability of worker i with x years of prior labor-market experience at period t will therefore be conditioned on the history of signals extracted from the observed outputs. Formally, this expectation is defined as:

$$\theta_{it}^{e} = E(\theta_i | z_{it-x}, ..., z_{it-1})$$

Because output is a linear function of effective ability, expected output at the beginning of period t, and therefore wages, will be based on expected effective ability (conditional on the information set of $t-1$). Task assignment in each period is then based on the maximization of current expected output.

The addition of imperfect information and learning does not change the ability of the model to explain the stylized facts discussed previously and allows the model to explain the possibility of real wage decreases. The main argument is based on the fact that this time, wages depend on expected innate ability whose evolution is now driven by the evolution of agents' beliefs. Because agents have rational expectations, expected innate ability follows a martingale process:

$$\theta_{it}^{e} = \theta_{it-1}^{e} + u_{it} \tag{4}$$

This means that the best *prediction* of future expected innate ability is current expected ability. In other words, any changes in current beliefs should be caused by the arrival of new information contained in the observed current output and could not be predicted from previous realized outputs.

The main difference with the perfect information case is that now, a worker's expected innate ability can fall from one period to the next if u_{it} is negative, and if the decrease is sufficiently large, it will dominate the increase due to human capital accumulation and next period wage will fall. For the same reason, there will be a positive frequency of demotions.

Serial correlation in wage increases continues to hold under the restriction of no demotions.[14] The reasoning is the same as in the perfect information case. Worker

[14]However, serial correlation in promotion rates is not a clear prediction of the model with learning. No matter how informative a worker's history of past output is, an extreme value of the next period output can radically change the beliefs for that period. See Gibbons and Waldman for a discussion on

who experience large wage increases between t and $t+1$ are worker for whom expected innate ability at $t+1$ has increased. This means that on average, the worker's expected effective ability will grow faster in the future. Large wage increases are thus positively correlated to large wage increases in the future.

The model gives predictions consistent with the fact that wage increases predict promotion. A large wage increase indicates an increase in expected innate ability which means that on average effective ability will grow more quickly in the future so that the worker will need less time to reach the target level of expected effective ability needed for promotion.

Finally, the size of the average wage increase on promotion is larger than the average wage increases before and, this time, after promotion. The worker promoted at the end of the period had a larger increase in expected effective ability than the worker not promoted. The wage increase will then be higher for this reason and also because the increase in expected ability will be valued at a bigger rate ($c_{j+1} > c_j$). After the promotion, the expected change in expected innate ability is zero so the wage increase is smaller on average than the wage increase at promotion. Wage increase at promotion explain a fraction of the difference in average wages across levels by the same argument on age and length of human capital accumulation as in the perfect information case.

In summary, the model under perfect information based on comparative advantage in the assignment of workers to job levels can explain the observed serial correlation in wage increases and promotion rates, the fact that wage increases predict promotions but that they explain only a fraction of the difference in average wages across levels. The introduction of learning allows the possibility of real wage decreases and that average wage increases are higher upon promotion than before and after promotion. Under particular hypothesis on η' and $\eta'' - \eta'$, defining intervals of effective ability in each job levels, the model leads to the prediction on absence of demotions. Thus, the model can explain the stylized facts highlighted in the literature on wages and intrafirm mobility.

The results of Section II, which suggest first the presence of an unmeasured indi-

---

this point.

vidual ability term and second, that there is evidence of workers' self-selection due to comparative advantage on measured ability, are consistent with the Gibbons and Waldman model. Given that unmeasured (or unobserved) ability is correlated with measured ability, evidence on the fact that workers also have a comparative advantage on unmeasured ability is expected to be found. To test more rigorously whether the model is supported by the data, a more sophisticated method than the first difference method has to be used. In the next Section, I present the econometric specification of the model and the estimation method which takes into account the comparative advantage and the learning principles based on innate ability.

3.2 Econometric Specification

Empirical evidence on inter-industry wage differentials has created controversy on the estimation method used to explain them. Gibbons and Katz (1992) have presented a theoretical model which emphasizes the importance of both endogenous mobility driven by the dynamic evolution of an unmeasured ability term and endogenous choice of industry or self selection of workers into industries due to the different sensitivity of industries' technologies with respect to this ability term. The model of Gibbons and Waldman formalizes these ideas in the context of the wage policy of the firm with endogenous choice of job levels and endogenous mobility between these job levels. The purpose of this Section is to present an econometric specification of the dynamic of wages implied by the model of Gibbons and Waldman where the endogeneity problems induced by the comparative advantage and the learning hypotheses can be accounted for and the relative importance of their effects on the dynamics of wages can be estimated.

The specification accounts for the general case of comparative advantage and learning (the model under imperfect information). That is, the process for wages, equation (3) is written using the expectation of workers' ability, θ^e_{it}.

In order to control for measurable individual characteristics, I included the skill variable defined previously. Employing dummies, D_{ijt}, indicating the rank j of individual i at time t, the equation to be estimated can be written as:

$$w_{ijt} = \sum_{j=1}^{J} D_{ijt} d_j + \sum_{j=1}^{J} D_{ijt} X_{it} \beta_j + \sum_{j=1}^{J} D_{ijt} c_j \theta_{it}^{e} f(x_{it}) + \mu_{it} \tag{5}$$

where μ_{it} is a measurement error independent of rank assignment, and X_{it} corresponds to the skill variable. Comparative advantage is characterized by the fact that the coefficients β_j and c_j vary by rank and learning is represented by the conditional expectation θ_{it}^{e}.

Estimating equation (5) with OLS would give inconsistent estimates. The comparative advantage hypothesis implies that rank assignment is endogenous, so θ_{it}^{e} is correlated with the rank dummies. In addition, this term cannot be eliminated by first-differencing (5) because it is interacted with the D_{ijt} terms. Holtz-Eakin, Newey and Rosen (1988) analyze models in which a fixed effect is interacted with year dummies and show that consistent estimates can be obtained by quasi-differencing the equation of interest and using appropriate instrumental-variable techniques. Lemieux (1998) applies this method to a model in which the return to a time-invariant unobserved characteristic is different in the union and the non-union sector. Gibbons, Katz and Lemieux (1997) also use this method to analyze wage differentials by industry and occupation in the presence of unmeasured and unobserved ability interacted with industry and occupation dummies. I apply this method to estimate the wage equation (5).

3.3 Estimation Method

The first step is to eliminate θ_{it}^{e} by quasi-differencing equation (5) in the following manner:

$$\theta_{it}^{e} = \frac{w_{ijt} - \sum_{j}^{J} D_{ijt} d_j - \sum_{j}^{J} D_{ijt} X_{it} \beta_j - \mu_{it}}{\sum_{j}^{J} D_{ijt} c_j f(x_{it})} \tag{6}$$

The martingale property of beliefs in innate ability which links θ_{it}^{e} and θ_{it-1}^{e} implies that we can substitutes a lagged version of this equation into (5). The final equation is therefore given by:

$$\begin{aligned} w_{ijt} &= \sum_{j=1}^{J} D_{ijt} d_j + \sum_{j=1}^{J} D_{ijt} X_{it} \beta_j + \frac{\sum_j^J D_{ijt} c_j f(x_{it})}{\sum_j^J D_{ijt-1} c_j f(x_{it-1})} \, w_{ijt-1} \\ &- \frac{\sum_j^J D_{ijt} c_j f(x_{it})}{\sum_j^J D_{ijt-1} c_j f(x_{it-1})} \, [\sum_{j=1}^{J} D_{ijt-1} d_j + \sum_{j=1}^{J} D_{ijt-1} X_{it-1} \beta_j] + e_{it} \end{aligned} \tag{7}$$

$$\text{where} \quad e_{it} = \mu_{it} + \sum_{j=1}^{J} D_{ijt} u_{it} - \frac{\sum_j^J D_{ijt} c_j f(x_{it})}{\sum_j^J D_{ijt-1} c_j f(x_{it-1})} \, \mu_{it-1} \tag{8}$$

This equation cannot be estimated using non-linear least square because w_{ijt-1} is correlated with μ_{it-1}. Moreover, because of the presence of learning, the new information on innate ability at time t, u_{it}, is correlated with D_{ijt} since beliefs on ability influences the current rank affiliation. These problems can be solved by choosing appropriate instruments for w_{ijt-1} and D_{ijt}, and consistent estimates will be obtained. Calling Z_i the set of instruments, these variables have to satisfy the following condition:

$$E(e_{it} Z_i) = 0 \tag{9}$$

The objective is then to minimize the following quadratic form:

$$\min_{\beta} e(\beta)' Z (Z' \Omega Z)^{-1} Z' e(\beta) \tag{10}$$

where $Z'\Omega Z$ is the covariance matrix of the vector of moments $Z'e(\beta)$, Ω is the covariance matrix of the error term e_{it} and β is the vector of parameters. Under homoscedasticity and serial independence of the error terms, $\Omega = I$ (up to a constant σ^2 which disappears in the minimization of (10)), so that the weighting matrix is equal to $Z'Z$ and the method gives a consistent Non-Linear Instrumental Variables estimator. An efficient estimator is obtained by estimating Ω. I will consider the two types of estimation using the SAS Non Linear IV procedure.

Finally, the unmeasured ability term θ_{it} in the error term of equation (5) has to be normalized to zero over the observations in order to identify all the parameters.[15] This

[15] A proof of the necessity of this constraint is given in Lemieux (1998).

is done by adding the following equation to the optimization of (10):

$$(1/TN)\sum_i \sum_t \underline{\theta_{it}} = 0 \tag{11}$$

where N is the number of individuals, T is the number of periods for each individual and $\underline{\theta_{it}}$ satisfies equation (6).

Instruments are chosen using the identification assumption for estimation of panel data equations that imposes strict exogeneity of right-hand side variables or more formally:

$$E(\mu_{it}/X_{i1}...X_{iT}, D_{ij1}...D_{ijT}, \theta_i) = 0 \tag{12}$$

The estimation has first been done under the assumption of perfect information on the ability term θ_i, focusing on the impact of comparative advantage and self-selection of workers into the different ranks with innate ability known to all market participants. In this case, the innovation driving the martingale process for beliefs disappears from the error term of equation (7) and the instruments are chosen to correct the correlation of lagged wage with the error term μ_{it-1}, resulting from the quasi-differencing method.

Condition (12) provides a set of potential instruments since it states that conditional on observed innate ability, individual characteristics and rank assignments each period are independent of the error term in the wage equation (5). In addition, since according to the production technology (equation (2)), new information contained in the observation of current output has the same impact across ranks, conditional on innate ability and other measurable characteristics, the current choice of job level is random. In the spirit of Lemieux's estimation of comparative advantage mentioned before, I consider as instruments for the lagged wage the history of job level or rank dummy variables. In particular, interaction terms between D_{ijt-1} and D_{ijt} which give information on the career path of the worker between $t-1$ and t, should help predict w_{ijt-1}. Indeed, according to the Gibbons and Waldman model, the choice of a job level is influenced by innate ability and should therefore be correlated to the wage but uncorrelated to the error term μ_{it} because of condition (12).

In the imperfect information case, the presence of learning introduces another correlation problem. Now that innate ability evolves over time as beliefs change, the current choice of job rank D_{ijt} is correlated to the changes in beliefs between t and $t-1$ (reflected in the martingale innovation u_{it} which appears in the error term e_{it}). Therefore, D_{ijt} will have to be instrumented. The choice of instruments will be facilitated thanks to the martingale process for innate ability which implies that changes in beliefs today are uncorrelated to changes in beliefs the period before. Therefore, it is possible to use the choice of job level in the previous periods, D_{ijt-2} and D_{ijt-1}, because they are correlated to the changes in expected ability in period $t-2$ and $t-1$ (helping predict D_{ijt}) but are uncorrelated to the current changes u_{it} and thus, uncorrelated to the error term e_{it} in the quasi-differencing equation. As before, interaction between D_{ijt-2} and D_{ijt-1} will also be considered. This set of variables will also provide valid instruments for w_{ijt-1} for the same reasons as in the case of perfect information.

The estimation results will be presented in two parts. First, equation (7) is estimated under the assumption of perfect information to emphasize the impact of comparative advantage on θ_i (observed by the market but unmeasured by the econometrician). Second, the estimation is performed for the model with comparative advantage and learning about θ_i.

Note that in both cases the element $\frac{f(x_{it})}{f(x_{it-1})}$, representing the ratio of accumulated experience in t with regard to $t-1$, has to be specified. According to the Mincer wage equation, wages when studied in log, are specified by a polynomial function of experience. Since wages here are in level, it should be reasonable to assume an exponential function of this same polynomial in experience. This leads to the following functional form for the ratio $g(x_{it}) = \frac{f(x_{it})}{f(x_{it-1})}$ [16]:

$$g(x_{it}) = b_0 e^{-b_1 x_{it}} \tag{13}$$

Going back to the Gibbons and Waldman model, the estimation of a ratio higher

[16] Assuming $f(x_{it}) = e^{\alpha_0+\alpha_1 x_{it}-\alpha_2 x_{it}^2}$ then $g(x_{it}) = e^{\alpha_1+\alpha_2-2\alpha_2 x_{it}}$.

than unity will confirm that the function f of human capital accumulation is non constant and monotonically increasing with experience. In other words, it will show evidence of unmeasured (unobserved in the learning case) heterogeneity in the accumulation of human capital and therefore in wage increases and mobility. According to the model, the evolution of the worker's productive ability over time (defined as the product of ability θ_i and the experience funtion f) is driven by an unmeasured ability term and since it enters linearly in the wage function, the wage dynamics will be driven by this θ_i term. As seen in Section II, this implies serial correlation in wage increases and in promotion rates as the firm observes (or expects) that some individuals perform better than others, it assigns them to higher ranks. They receive higher wage increases not only as a result of mobility between ranks but also within a rank as they vary across workers of different type θ_i [17].

4 Results and Interpretations

The analysis of the results is presented in four parts. The first part focuses on the estimation of the wage dynamics for workers remaining inside their firm (Table 2.3). The second part performs the same estimations but this time with the sample including workers changing firms to study the possible differences in the impact of measured and unmeasured (unobserved) ability on the wage dynamics (Table 2.4). The third part concentrates on the estimation of the human capital accumulation ratio (Table 2.5). The last part considers the estimation with non homoscedastic errors and the problem of classification errors in the rank variables (Table 2.6).

4.1 Wage Dynamics Within Firms

Results, shown in the first part of Table 2.3, confirm the importance of non random selection of workers based on unmeasured ability. The coefficients c_j which evaluate the impact of unmeasured ability in each rank j are significant. Starting at 1 (normalization)

[17] With an estimated b_1 significant, the ratio will vary with experience which implies that accumulation of human capital would not only vary across workers but also over time.

for rank L, they range from 1.043 for the middle rank M, to 1.475 for the upper rank U and 1.600 for the executive rank E. They are significantly different from one another according to the joint test ($\chi^2(3)$ of 15.00) and, expcept for rank M, are also significantly different from the lower rank L ($\chi^2(1)$ of 10.10 for U and 4.69 for E). These results suggest distinct and increasing returns to unmeasured ability by hierarchical level.

The inter-rank wage differentials d_j have dropped by about 80% compared to the OLS results in column (4) of Table II when only comparative advantage on measured skills is considered. The coefficients related to measured skills by rank (the β_j) are still significantly different from one another ($\chi^2(3)$ of 6.12 for the joint test) implying that comparative advantage on measured ability is still important but compared to column (4) of Table II, its impact is smaller. One can also notice that their impact is now decreasing with ranks, ranging from 0.735 in rank L to being not significantly different from 0 in the highest rank E. In summary, non random selection or comparative advantage of workers based on unmeasured ability seems to capture an important part of the variation in the dynamics of wages within the firm and the part related to measured ability becomes less and less important as workers go up the ladder. Although significantly reduced, the rank effects are still significant.

The second part of Table 2.3 reports the results of the model when learning about unobserved ability is considered. One can see that only the rank effect for the middle rank M is significant. Moreover, except for rank M and c_M, the slopes associated with unobserved ability are not different from one another and not different from the lower rank slope. The slopes associated with measured ability remain significant at all rank. Generally, the standard errors of the coefficients are larger than in the case with no assumption of learning. Results are more imprecise and hard to interpret. In fact, except for the middle rank M, the c_j which measure the impact of unmeasured ability (unobserved in this case) in each rank are no longer increasing in ranks. From these results, it is rather difficult to conclude on the effects of learning on the wage dynamics. The overall imprecision of the results might come from the use of second and third lags of the variables for the instruments. This lead to a substantial loss of observations.

In both estimations, the human capital accumulation ratio has been estimated as a constant term b_0 and one can see that in the comparative advantage case, it is significantly different from one. Its estimated value of 1.024 gives, in log, a 2.37 % growth rate for the function f of human capital accumulation. In other words, controlling for all other measurable individual characteristics, one more year of experience within the firm is associated with a 2.37 % wage increase for the average worker. In the specification with learning, the ratio is not significantly different from one, implying that the function f is constant or that there is no evidence of unobserved heterogeneity in the workers' human capital accumulation.

Finally, note that in both estimations, the over-identification test [18] shows that the instruments used are valid since the null cannot be rejected.

Summarizing the overall results, one can say that the dynamics of wages and the workers' mobility within the firm are characterized by the importance of non random selection of workers into job ranks and by the presence of unmeasured heterogeneity in human capital accumulation leading to the result that wage increases are serially correlated. The unconclusive results on the presence of learning as the factor driving the worker's mobility across job ranks, suggests that German workers are not mobile within the firm. Once they enter the firm, they get to the job rank that best suit their productive abilities and remain in that job thereafter. A possible explanation for that is the importance of the apprenticeship system in Germany. In this system, individuals receive training within a firm for a certain period of time while still completing school. During that period, both the firm and the worker can get information on the productivity of the employer-employee match and both can use it in their future employment decisions. Since the sample studied considers individuals just after entering the labor force on a permanent basis, those working while still completing school have not been considered.

The results on serial correlation in wage increases (controlling for measurable individual characteristics) is in contrast with the literature mentioned earlier on the absence of serial correlation when estimating the covariance structure of wages and wage residuals

[18] The statistic of the test uses the optimized value of the objective function times the number of observations. The distribution is $\chi^2(l-p)$ where p is the number of parameters and l is the number of instruments.

(Abowd and Card (1989) and Topel and Ward (1992). However, it is in accordance with studies that analyzed the question with particular samples of workers (Hause (1980) who uses a sample of white-collar Swedish males and Lillard and Weiss (1979) who study a sample of American scientists). In the analysis so far, I considered the sample of workers remaining with their firms and the heterogeneity captured in the results could be worker-firm specific rather than individual specific. To examine whether the effects of heterogeneity in human capital accumulation, comparative advantage and learning driving the wage dynamics are more individual or worker-firm specific, I estimate, in the next Section, the model over a sample that includes firm changers.

4.2 Wage Dynamics Within and Between Firms

The results from performing the estimations on the sample of workers moving within and between firms are presented in Table 2.4. They are similar to those obtained with the sample of firm stayers concerning the presence of non random selection and comparative advantage. One can notice increasing effect of unmeasured ability and decreasing effect of measured skills with ranks. Rank effects are also still significant. Also, the second part of the Table shows, as before, no clear evidence of learning. [19]

In the comparative advantage case, the differences between the estimations over the two samples lies in the magnitude of the slope coefficients related to unmeasured ability and measured skills for the different ranks. The slope associated with unmeasured ability at the highest executive rank E and the ones related to measured skills at the lower ranks L, M and U are now higher. More precisely, for the slope coefficients on unmeasured ability, the effect c_E is twice as high as the one at the lowest rank L which is higher than in the previous results (c_E is 2.02 compared to 1.6 in Table 2.3). On the other hand, the coefficients associated with middle and upper ranks c_M and c_U are similar to those of Table 2.3. The slope coefficient on measured skills is non significant at the highest rank E like in the previous case but the coefficients β_L, β_M and β_U are much higher now than in Table 2.3.

[19] Because learning does not seem to be supported by the data, the analysis thereafter focuses on the specification with comparative advantage only.

These results suggest that the impact of unmeasured ability on the wage dynamics seems to be more individual specific at the executive rank. At the lower ranks, the inclusion of firm changers did not change the impact of unmeasured ability as much. On the other hand, the impact of measured skills is higher at these ranks when observations on the worker's mobility between firms are included in the sample. It can be concluded from these results that the effect of unmeasured ability at the lower, middle and upper ranks does not seem to result from an individual specific ability effect that would be transferable across firms but should result from a worker-firm specific match quality effect.

In summary, the wage policy of firms is characterized by the importance of non random selection of workers into job ranks and the existence of unmeasured heterogeneity in wage increases. This result is surprising given that the German labor market is regulated by unions and employers' associations which would suggest that pay settings are more related to bureaucratic rules. On the other hand, I find evidence that the rank effects d_j are still significant even after controlling for measured and unmeasured characteristics. Note that these coefficients always increase with ranks which is not in accordance with the Gibbons and Waldman model's assumption that they should be decreasing with ranks. In the model, wages are set according to a piece-rate pay system based on expected output. Both the slopes and intercepts are parameters that are given to the firm but depend on the equilibrium allocation of the workers' skills to job ranks. Workers with low level of skills or performance are assigned to (and also choose) low job ranks, where the wage puts the least weight on skills, i.e. with a high intercept and a flat slope. The highly skilled worker ends up in a high job rank with a wage mostly based on skills (with a low intercept and a high slope). This negative correlation between the intercept and the slope is not as clear when wages are not only function of skills but also depend on the firm's bureaucratic rules. The results here suggest that the intercepts or rank effects reflect more administrative settings specific to the job such as task complexity and responsibility requirements which increase with rank independently of the worker's skill level.

4.3 Human Capital Accumulation

The results so far come from the estimation of the wage equation with a constant ratio of human capital accumulation. Workers accumulate years of experience within the firm at different rates but no matter what period of time in the worker's career, one additional year of experience has the same impact. One might think however that the impact is stronger at the beginning than at the end of the worker's career. I reestimated the model considering the more general functional form given in (13). Results are shown in Table 2.5 for the comparative advantage case[20]. The ratio has been estimated as a function of the number of years of tenure with the firm. The estimation using the number of years of potential experience did not lead to the convergence of the objective function in the optimization process. Also, convergence could not be reached for no other functional form for the ratio than the one shown in table V, where the coefficient b_0 is constrained to be equal to one. Finally, the two parts of the Table relate to the estimations on the two different samples used previously.

For the results on the presence of non random selection of workers into job ranks, one can see that the conclusions are the same as before. The coefficients on measured and unmeasured ability and the rank effects are similar to those from the first part of Tables III and IV with comparative advantage only and a constant ratio. For the results on the estimation of the ratio, the impact of tenure (coeffient b_1) is significant but very small and, contrary to what was expected, it is positive.[21] The ratio is in fact very close to one for the first year of tenure (ratio of 1.001) and still remains close to it after 10 years (ratio of 1.01) leading to estimated wage increases of 0.1 % and 1 % respectively. Therefore, one can reasonably conclude that the ratio does not seem to vary with the worker's tenure in the firm.

[20] Results with learning, available on request, did not lead to a significant estimation of the coefficients b_0 and b_1.

[21] According to the human capital theory, one additional year of experience should have a decreasing impact with increasing years of experience with the firm.

4.4 Discussion of the Results

Despite the preceding evidence on non random selection of workers onto the hierarchical levels of the firm's job ladder and on unmeasured ability driving the dynamics of wages, there are several issues to keep in mind in anlysing the results. Among those is the assumption of homoscedasticity of the error term. Since this might be a strong hypothesis, I reestimated the equation, using an estimate of Ω in a second step, where the first step estimates by NLIV with $\Omega = I$, using the residuals from the estimation in the first step to estimate Ω (Hansen (1982)). The results of this estimation are presented in the first part of Table 2.6 for the comparative advantage case.

Generally, correcting for possible heteroscedasticity and/or autocorrelation of the error term lead to more imprecise estimates. The results are quite different from those in Table 2.3 in terms of the magnitude and also standard errors of the coefficients. Moreover, the value of the statistic of the overidentification test is now quite high (58.99) leading to reject the hypothesis of valid instruments.

The fact that the statistic of the test (based on the optimized value of the objective function) has a larger value when the covariance of the moments is estimated does not have a clear explanation since there is no reason to expect that $(Z'\Omega Z)^{-1}$ should be larger than $(Z'Z)^{-1}$. On the other hand, Altonji and Segal (1994) show that although the choice of the weighting matrix as the variance of the moments gives an efficient GMM estimator asymptotically, it leads to an estimator which has poor small sample properties. Using Monte Carlo experiments they find that the estimator is biased because sampling errors in the moments to be estimated are correlated with sampling errors in the weighting matrix (which is a function of the covariance of these moments). This may explain why the coefficients found and the value of the objective function are very different. Given that the sample is not unreasonably large the results without the estimation of the weighting matrix, which still provide consistent estimates, may be favored.

Another issue that has to be stressed is the presence of classification errors in the reported occupation ranks from year to year. Assuming that these errors are serially uncorrelated, I reestimated the model with comparative advantage using the second lags of the variables. Results, reported in second part of Table 2.6 are slightly different from those of Table 2.3. All the coefficients have larger standard errors and the b_j coefficients lose their expected increasing order by rank. This suggests that classification errors might be important.

5 Conclusion

In this paper, I have analyzed the relative importance of different factors explaining what is driving the dynamics of wages and the workers mobility within firms. To do this, I implemented empirically the theoretical model proposed by Gibbons and Waldman (1999) that combines the notions of human capital accumulation, job level assignments based on comparative advantage and learning about the worker's ability to characterize the wage policy of firms.

Using survey data for a large sample of workers I can draw conclusions on the common features arising from the wage policy of firms for a large sample of firms. The longitudinal dimension of the data allows me to analyze the wage and mobility dynamics. Based on the German GSOEP over the years 1986 to 1996, the results can be summarized in the following points.

The main common features characterizing the wage policy of German firms are the importance of non random selection of workers into job ranks and the evidence of heterogeneity in human capital accumulation leading to serial correlation in wage increases. Whether the source of heterogeneity is more individual specific or related to the quality of the match worker-firm seems to depend on the job rank considered. The unmeasured ability term at the executive rank has a larger effect on the wage dynamics when it is estimated over the sample of workers moving inside the firm as well as changing firms. The effects at the lower, middle and upper ranks of the worker's occupation are similar whether or not firm changers are included in the sample.

The results of this paper reveal the importance of the question of assignment of workers to job ranks on our understanding of wage dynamics within as well as between firms. The evidence on the presence of non-random selection of workers onto the rungs of the job ladder brings an additional explanation for the fact that the distribution of wages differ from the distribution of individual productivities at the level of the firm. These results show that wage dynamics within the firm depend not only on the worker's ability (innate ability or quality of the match worker-firm) but also on how productive this ability (or match) is within a specific job rank. In addition, the fact that the rank premia remain significant even after controlling for measured and unmeasured heterogeneity in the wage dynamics suggests that the firm's administrative rules constitute another relevant explanatory factor.

The estimation of the model of Gibbons and Waldman lead to a relatively good description of the German case and it would obviously be interesting to compare them with US data. To my knowledge, there is no American survey data with a question on the job rank of the worker. However, it would be possible to construct variables on job levels by using the three-digit codes from the US Census which provide a detailed classification of occupations. Future research should investigate this issue because if the model of Gibbons and Waldman provides a reasonable explanation of wage dynamics in German firms it may be even more relevant in US firms (where the mobility of the workers, on which the model is based, is higher than in Germany).

The model of Gibbons and Waldman is based on the assumption that all firms are identical and therefore have the same hierarchical structure and the same production technology. Further research could investigate the possibility that firms of different size differ in their internal organization as suggested by the empirical evidence on the impact of firm size on wage outcomes (see for example Brown and Medoff (1989)). This could imply that the productivity of a given worker-job-level match is different in large and small firms. The effects of this kind of assumption on the ability to explain wage dynamics is a possibility that future research might consider.

Finally, one thing that is absent in the model of Gibbons and Waldman is the role of incentives in the determination of the wage policy of firms. This is clearly a relevant point when modeling the factors driving the worker's mobility within the firm and the resulting wage increases. Lazear (2001) analyzes the question of explaining the observed decline in the worker's productivity after a promotion. Using the Gibbons and Waldman theoretical framework, he explains the firm's strategic decision of who and when to promote workers in order to minimize the post promotion productivity decline. Given that the Gibbons and Waldman model is easily implementable empirically, future research should investigate the possible empirical applications of the augmented model that considers the role of incentives.

Table 1: Logit Estimation of Intrafirm Mobility[a]

Model[b]	Baseline Specification	Marg. Effect	Lagged Bonus	Lagged Wage Gr.	All Variables	Marg. Effect
High Sc.	0.293	0.011	0.249	0.048	0.052	0.001
	(0.181)		(0.189)	(0.337)	(0.336)	
College	0.566***	0.022	0.557**	0.508	0.505	0.010
	(0.216)		(0.225)	(0.387)	(0.236)	
Tenure	-0.086***	-0.002	-.0008	-0.098**	-0.100**	-0.001
	(0.022)		(0.027)	(0.041)	(0.041)	
German	0.138	0.005	0.262	0.112	0.106	0.002
	(0.227)		(0.229)	(0.431)	(0.432)	
Female	-0.181	-0.007	-0.275***	-0.088	-0.088	-0.002
	(0.119)		(0.126)	(0.203)	(0.203)	
Married	-0.334***	-0.013	-0.299***	-0.316*	-0.315*	-0.006
	(0.112)		(0.116)	(0.192)	(0.192)	
Size	0.634***	0.025	0.733***	0.531***	0.526***	0.010
	(0.112)		(0.121)	(0.180)	(0.180)	
Contract	-0.149	-0.006	0.214	-0.322	-0.335	-0.006
	(0.221)		(0.241)	(0.389)	(0.388)	
Public	0.188	0.007	0.225	0.268	0.257	0.005
	(0.174)		(.180)	(0.267)	(0.270)	
Lbonus	-	-	-1.888***	-	0.329	0.006
			(0.144)		(0.441)	
LwageGr	-	-	-	2.280***	2.293***	0.041
				(0.744)	(0.744)	

a-The number of observations for $y = 1$ is 638 over a total of 14493.
b-All specifications include dummies for industry, occupations and a quadratic function of tenure and a cubic function of the wage growth rate.
***= significant at 1 %. **= significant at 5 %.*= significant at 10 %.

Table 2: Wage Differentials by Job Rank

Models[a]	(1)	(2)	(3)	(4)
Variables[b]	OLS	OLS	FE	OLS with CA
Skill	-	1.589***	1.653***	-
		(0.034)	(0.092)	
Rank L		-	-	-
Rank M	0.357***	0.121***	0.021*	0.20***
	(0.019)	(0.016)	(0.015)	(0.020)
Rank U	1.373***	0.684***	0.157***	0.70***
	(0.039)	(0.035)	(0.019)	(0.039)
Rank X	2.195***	1.204***	0.219***	0.92***
	(0.077)	(0.068)	(0.032)	(0.119)
Skill*Rank L	-	-	-	1.21***
				(0.041)
Skill*Rank M	-	-	-	1.53***
				(0.065)
Skill*Rank U	-	-	-	1.99***
				(0.082)
Skill*Rank X	-	-	-	2.37***
				(0.180)
Adj. R2	0.48	0.62	0.11	0.63
Observations	11159	11159	11159	11159
Test of Equality of slopes				103.43
p-value of the χ^2-test				.000

a-Dependent variable is wage in level in thousand of marks. Standard errors have been computed using the White correction.
b-Are also included are dummies for the type of contract, large firm size, public sector, occupations, industries and years.

Table 3: Wage Dynamics Within Firms[a]

Comparative Advantage

Specification[b] 1	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.051	0.095*	0.195***
		(0.035)	(0.053)	(0.062)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.043***	1.475***	1.600***
		(0.081)	(0.149)	(0.277)
Measured	β_L	β_M	β_U	β_E
	0.735***	0.728***	0.411***	0.032
	(0.121)	(0.139)	(0.157)	(0.349)
Ratio	b_0			
b_0	1.023***			
	(0.006)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	15.00 (0.00)	0.28 (0.59)	10.10 (0.00)	4.69 (0.03)
of Slopes β_j	6.12 (0.10)	0.01 (0.92)	3.70 (0.05)	4.04 (0.04)
of Ratio $b_0 = 1$	16.27 (0.00)			
Overidentification Test[c]	17.10 (0.99)			

Comparative Advantage and Learning

Specification[b] 2	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.104**	0.006	0.036
		(0.038)	(0.047)	(0.092)
Skill*Ranks				
Unobserved	c_L	c_M	c_U	c_E
	1	1.204***	1.021***	0.967***
		(0.133)	(0.127)	(0.182)
Measured	β_L	β_M	β_U	β_E
	0.473**	0.364**	0.609***	0.492*
	(0.192)	(0.150)	(0.133)	(0.262)
Ratio	b_0			
b_0	1.008***			
	(0.006)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	9.47 (0.03)	2.33 (0.13)	0.03 (0.86)	0.03 (0.86)
of Slopes β_j	3.83 (0.28)	0.63 (0.43)	0.53 (0.47)	0.00 (0.95)
of Ratio $b_0 = 1$	2.00 (0.15)			
Overidentification Test[c]	13.11 (0.99)			

a-Dependent variable is wage in level in thousand of marks. Also included are dummies for the type of contract, large firm size, public sector, occupations, industries and years.

b-Estimation using $\Omega = I$. Number of observations is 11159 in the comparative advantage case and 9891 in the learning case.

c-χ^2-test with p-value in parenthesis.

Table 4: Wage Dynamics Within and Between Firms[a]
Comparative Advantage

Specification[b] 1	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.058*	0.118**	0.181*
		(0.032)	(0.051)	(0.076)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.079***	1.486***	2.019***
		(0.080)	(0.177)	(0.362)
Measured	β_L	β_M	β_U	β_E
	0.989***	0.986***	0.746***	0.019
	(0.121)	(0.134)	(0.138)	(0.377)
Ratio	b_0			
b_0	1.024***			
	(0.006)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	14.72 (0.00)	0.97 (0.32)	7.58 (0.00)	7.94 (0.00)
of Slopes β_j	7.00 (0.07)	0.00 (0.95)	2.28 (0.13)	6.64 (0.01)
of Ratio $b_0 = 1$	13.80 (0.00)			
Overidentification Test[c]	21.48 (0.88)			

Comparative Advantage and Learning

Specification[b] 2	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.077*	0.004	-0.018
		(0.044)	(0.047)	(0.115)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.078***	0.897***	1.032***
		(0.126)	(0.118)	(0.213)
Measured	β_L	β_M	β_U	β_E
	0.634***	0.672***	0.807***	0.363
	(0.183)	(0.144)	(0.124)	(0.294)
Ratio	b_0			
b_0	1.009***			
	(0.006)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	9.72 (0.02)	0.38 (0.54)	0.76 (0.39)	0.02 (0.88)
of Slopes β_j	3.89 (0.27)	0.11 (0.74)	1.03 (0.31)	0.71 (0.40)
of Ratio $b_0 = 1$	2.08 (0.15)			
Overidentification Test[c]	14.47 (0.99)			

a-Dependent variable is wage in level in thousand of marks. Also included are dummies for the type of contract, large firm size, public sector, occupations, industries and years.
b-Estimation using $\Omega = I$. Number of observations is 11929 in the comparative advantage case and 10439 when learning is considered.
c-χ^2-test with p-value in parenthesis.

Table 5: Wage Dynamics and Human Capital Accumulation Ratio[a]
WITHIN FIRMS

Estimation[b] 1	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.098*	0.129***	0.223***
		(0.040)	(0.046)	(0.054)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.166***	1.393***	1.459***
		(0.097)	(0.128)	(0.246)
Measured	β_L	β_M	β_U	β_E
	0.697***	0.587***	0.499***	0.217
	(0.113)	(0.149)	(0.149)	(0.313)
Tenure Ratio	b_0	b_1		
$b_0 e^{b_1 x_{it}}$	1	0.001***		
		(0.0004)		
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	18.67 (0.00)	2.85 (0.09)	9.44 (0.00)	3.48 (0.06)
of Slopes β_j	5.48 (0.14)	1.27 (0.26)	1.72 (0.19)	2.36 (0.12)
Overidentification Test[c]	19.39 (0.95)			

WITHIN AND BETWEEN FIRMS

Estimation[b] 2	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.104***	0.156***	0.214*
		(0.037)	(0.042)	(0.065)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.202***	1.353***	1.766***
		(0.095)	(0.145)	(0.310)
Measured	β_L	β_M	β_U	β_E
	0.903***	0.842***	0.829***	0.249
	(0.112)	(0.141)	(0.129)	(0.334)
Tenure Ratio	b_0	b_1		
$b_0 e^{b_1 x_{it}}$	1	0.001***		
		(0.0005)		
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	16.28 (0.00)	4.54 (0.03)	5.95 (0.01)	6.10 (0.01)
of Slopes β_j	5.04 (0.17)	0.84 (0.35)	0.27 (0.60)	3.86 (0.05)
Overidentification Test[c]	21.85 (0.88)			

a-Dependent variable is wage in level in thousand of marks. Also included are dummies for the type of contract, large firm size, public sector, occupations, industries and years. Both estimat--ions are performed for comparative advantage case.
b-Estimation using $\Omega = I$. Number of observations is 11159 for the sample of moves within firms and 11927 when moves between firms are included.
c-χ^2-test with p-value in parenthesis.

Table 6: Wage Dynamics Estimation[a]

ESTIMATION WITH NON HOMOSCEDASTIC ERRORS

Estimation[b] 1	Low	Middle	Upper	Executive
	Rank L	Rank M	Rank U	Rank E
Ranks	d_L	d_M	d_U	d_E
	-	0.108*	0.088	0.155*
		(0.061)	(0.089)	(0.087)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	1.212***	1.583***	1.285***
		(0.159)	(0.214)	(0.349)
Measured	β_L	β_M	β_U	β_E
	1.134***	1.088***	0.965***	1.098
	(0.168)	(0.205)	(0.270)	(0.320)
Ratio	b_0			
b_0	1.003***			
	(0.008)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	8.71 (0.03)	1.78 (0.18)	7.39 (0.00)	0.67 (0.41)
of Slopes β_j	1.27 (0.73)	0.43 (0.51)	0.81 (0.39)	0.02 (0.89)
of Ratio $b_0 = 1$	0.13 (0.72)			
Overidentification Test[c]	58.99 (0.00)			

ESTIMATION WITH SECOND QUASI-DIFFERENCING

Estimation[d] 2	Low	Middle	Upper	Executive
Ranks	d_L	d_M	d_U	d_E
	-	0.019	0.135**	0.187
		(0.076)	(0.068)	(0.117)
Skill*Ranks				
Unmeasured	c_L	c_M	c_U	c_E
	1	0.874***	0.826***	1.129***
		(0.199)	(0.219)	(0.275)
Measured	β_L	β_M	β_U	β_E
	1.192***	1.268***	1.283***	0.987
	(0.261)	(0.158)	(0.167)	(0.336)
Ratio	b_0			
b_0	1.029***			
	(0.012)			
Tests[c] for Equality	Joint	M=L	U=L	E=L
of Slopes c_j	16.27 (0.00)	0.40 (0.53)	0.62 (0.43)	0.22 (0.64)
of Slopes β_j	1.78 (0.62)	0.16 (0.68)	0.15 (0.70)	0.35 (0.55)
of Ratio $b_0 = 1$	5.42 (0.02)			
Overidentification Test[c]	31.76 (0.80)			

a-Dependent variable is wage in level in thousand of marks. Also included are dummies for the type of contract, large firm size, public sector, occupations, industries and years. Both estimat- -ions are performed for the comparative advantage case.
b-Estimation of Ω using the residuals from NLIV with $\Omega = I$ in a first step.
c-χ^2-test with p-value in parenthesis.
d-Estimation using variables in t and $t-2$ in the wage equation. Number of observations is 7775.

Appendix 1: Data Selection

First selection:
First selection on age and employement status (full-time, regular part-time or training within the firm). The sas dataset has 61787 observations.

Sample selection for the frequency computations:
Constructions of dummies for individual characteristics, industries and mobility (from the information on changes in employment situation). Selection of monthly nominal wages over 500 marks and computation of wage growth. Exclusion of self-employed workers and computation of weights as relative to the mean weight. The resulting dataset has 41793 observations. Final corrections of intersections between industries and occupations gives the dataset used for the frequency analysis with 32493 observations.

Selection for logit and wage estimations (OLS and GMM):
Supplementary exclusion because of problems in the construction of dummies for ranks within occupations (trainee is considered as a position with two levels trainee or student trainee but these two levels are not comparable with the ranks of white-collared or of other type of positions). They have thus been excluded. Moreover, one of the levels for white-collar workers is non tenured foreman which is difficult to associate with one of the 4 ranks considered. They have thus been excluded. The use of lags in estimations reduced the number of observations to 11929. Further selection of workers who remain within their firm (without change or with intrafirm mobility) lead to the use of 11159 observations for the logit model and the OLS and GMM estimations.

Sample Statisctics (Weighted) GSOEP- All Workers

Real monthly Wage (DM 1985) after Tax	2280.9
Years in School	11.5
Age	36.2
Percentage Female	42.3
Percentage German	90.9
Percentage Blue-Collars	40.2
Percentage White-Collars	47.5
Percentage Civil Servant	9.8
Percentage Trainees	2.5
Number of Observations	32492
Number of Individuals	6171

Sample Statisctics (Weighted) GSOEP- Workers Within Firm

Real monthly Wage (DM 1985) after Tax	2177.72
Years in School	11.1
Age	41.7
Percentage Female	38.5
Percentage German	70.3
Percentage Blue-Collars	53.4
Percentage White-Collars	38.4
Percentage Civil Servant	8.2
Number of Observations	11159
Number of Workers	3487

Appendix 2: Frequency of Mobility and Wage Growth

The possible answers to the question on the changes in employment situation since the preceding year are as follows:

1. no change
2. have a job with a new employer
3. became self-employed
4. have changed position within the firm
5. took up a job for the first time in my life
6. gone back to work after a break

I have categorized the different changes in employment situation into four groups: "No changes" "Separations", "Intrafirm Mobility" and "Other". Answers 2 and 3 are considered as separations, 4 as intrafirm mobility and 6 as other types of moves. I considered workers in the firm for at least one period so observations on answer 5 have been excluded from the sample. Frequencies conditional on potential experience and gender are presented in the Appendix 2.1 Table below. 89% of the workers surveyed experience no changes in employment situation. Among the 11% who are mobile, one half experienced separations while intrafirm mobility accounts for one fourth of the moves. Note also that all types of mobility declines with experience. The percentage of separations is high during the first ten years of experience but decreases rapidly after. Intrafirm mobility declines less rapidly than separations. Note that men experience fewer changes in employment situation than women.

Mean wage growth associated with the four categories of changes is provided in the Appendix 2.2. Based on the difference in the log of current and lagged real wages after deductions for tax and social security (compared to gross earnings, net earnings have been reported more frequently). The Table shows that the mean wage growth resulting from intrafirm mobility is relatively important and quite close to the wage growth workers experience after separations. Since separations are defined to include only moves to a new employer or to self-employment, one might suspect that most of those separations are voluntary and therefore associated with important wage growth.

Appendix 2.1: Frequency of Mobility by Experience (GSOEP)

Experience	No Change	Separation	Intrafirm Mobility	Other	N
Men					
0-10	70.6	17.6	5.7	6.2	2869
11-20	87.6	7.4	3.6	1.5	5368
21-30	94.3	2.6	2.2	0.9	5483
31-	96.7	1.8	1.3	0.7	7010
Total	90.1	5.5	2.7	1.7	20730
Women					
0-10	73.2	15.9	5.8	5.1	2468
11-20	84.2	6.5	3.2	6.0	2983
21-30	89.4	4.8	1.9	3.9	2955
31-	95.5	1.2	1.3	0.4	3356
Total	86.4	6.7	2.8	4.1	11762
Total	88.8	5.9	2.7	2.5	32492

Appendix 2.2: Wage Growth Associated with Mobility (GSOEP)

Experience	No Change	Separation	Internal Mobility	Other	N
Men					
0-10	.049 (*.005*)	.113 (*.02*)	.102 (*.02*)	.073 (*.04*)	.063 (*.005*)
11-20	.029 (*.002*)	.072 (*.01*)	.080 (*.01*)	.031 (*.14*)	.033 (*.002*)
21-30	.016 (*.002*)	.059 (*.03*)	.033 (*.01*)	.056 (*.04*)	.017 (*.002*)
31-	.009 (*.002*)	.010 (*.04*)	.045 (*.01*)	-.213 (*.14*)	.010 (*.002*)
Total	.020 (*.001*)	.082 (*.01*)	.071 (*.008*)	.024 (*.04*)	.025 (*.001*)
Women					
0-10	.039 (*.004*)	.125 (*.02*)	.158 (*.03*)	.036 (*.09*)	.060 (*.005*)
11-20	.026 (*.003*)	.111 (*.03*)	.078 (*.02*)	.065 (*.05*)	.034 (*.004*)
21-30	.022 (*.003*)	.048 (*.02*)	.042 (*.02*)	.061 (*.08*)	.024 (*.003*)
31-	.014 (*.003*)	.144 (*.05*)	.029 (*.01*)	.149 (*.04*)	.016 (*.003*)
Total	.023 (*.002*)	.107 (*.01*)	.099 (*.01*)	.077 (*.03*)	.030 (*.001*)
Total	.021 (*.001*)	.092 (*.008*)	.081 (*.007*)	.048 (*.03*)	.027 (*.001*)

Appendix 3: Average Characteristics by Rank [A]

Position	Wage Diff[b]	Edu. (Yr)	Exp. (Yr)	Woman (%)	German (%)	Married (%)	Skill Index
Blue-C							
Unskilled	0	9.4	27.8	63.3	64.5	63.7	-0.29
Semi-skilled	0.37	9.8	26.8	41.1	79.2	60.8	-0.14
Skilled	0.66	10.6	22.4	9.5	89.2	49.5	0.01
Foreman	1.05	10.4	26.6	3.1	92.8	80.5	0.09
Master Crafts.	1.11	10.9	25.9	1.42	98.4	61.3	0.11
White-C							
Simple duties	0	10.9	22.2	81.8	94.6	48.4	-0.30
Qualified	0.64	11.8	21.7	62.7	96.5	50.7	-0.12
Managerial	2.09	14.3	21.9	25.1	96.2	65.5	0.31
C.E.O	2.85	13.8	27.0	0.59	98.2	48.9	0.34
Civil Servant							
Lower	0	10.7	25.4	14.4	100	64.5	0.01
Middle	0.50	11.5	21.5	23.1	100	58.2	0.07
Upper	1.23	14.9	22.3	36.7	99.6	64.2	0.30
Executive	2.24	17.7	24.6	14.8	99.8	77.5	0.65
Aggregate[c]							
Rank 1	0	10.1	25.5	58.9	82.7	56.9	-0.21
Rank 2	0.49	11.3	21.9	39.0	94.0	50.8	-0.05
Rank 3	1.67	13.9	22.7	25.1	96.6	67.1	0.28
Rank 4	2.46	16.1	25.3	14.4	99.1	66.2	0.52